How Processing And Storage Affect Honey Quality

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JONATHAN W. WHITE, JR., MARY H. SUBERS, AND IRENE KUSHNIR
Eastern Regional Research Laboratory[1], Philadelphia 18, Pennsylvania

TO KEEP HONEY in its original condition of high quality and delectable flavor and fragrance is possibly the greatest responsibility of the beekeeper and honey packer. At the same time it is an operation receiving perhaps less attention from the producer than any other, and one requiring careful consideration by packers and wholesalers. To do an effective job, one must know the factors which govern honey quality, as well as the effects of various beekeeping and storage practices upon honey quality. The factors are easily arrived at, but only recently are the facts becoming known regarding the effects of storage and processing temperatures on honey quality.

To be of highest quality, a honey (be it liquid, crystallized, or comb) must be well-ripened with proper moisture content, be free of extraneous materials such as excessive pollen, dust, insect parts, wax, crystals if liquid; it must not ferment and, above all, must be of excellent flavor and aroma, characteristic of the particular honey type. It must, of course, be free of off-flavors or odors of any origin; in fact, the more closely it resembles the well-ripened honey as it exists in the cells of the comb, the better it is.

Factors Affecting Quality of Harvested Honey

There are a number of beekeeping practices which can reduce the quality of the extracted product. Such things as failure to avoid mixing of inferior floral types either by mixing at extracting time or removing the crop at incorrect times, extraction of unripe honey, extraction of brood combs, delay in settling and straining, are not under discussion here. We are concerned with the handling of honey from the extraction to the point of sale. During this time improper settling, straining, heating, and storage conditions can make a superb honey into just another commercial product.

Why Process Honey?

The primary objective of all processing of honey is simple - to stabilize it. This means to keep it free of fermentation and to keep the desired physical state, be it liquid or finely granulated. Methods for accomplishing these objectives have been fairly well worked out and have been in use for many years. Probably improvements can be made. The requirements for stability of honey are more stringent now than in years past, with honey a world commodity and available in super-markets the year around. Government price-support and loan operations require storage of honey, and market conditions may also require storage at any point in the handling chain - producer, packer, wholesaler, exporter, and so on.

1 Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

The primary operation in the processing of honey is the application and control of heat. If we consider storage to be the application of (or exposure to) low amounts of heat over long periods, it can be seen that a study of the effects of heat on honey quality can have a wide application.

Any assessment of honey quality must include flavor considerations. The objective measurement of flavor changes, particularly where they are gradual, is most difficult. In the work described in this article we have measured the accumulation of a decomposition product of the sugars (hydroxymethylfurfural or HMF) as an index of heat-induced chemical change in the honey. Changes in flavor (other than simple loss by evaporation) may also be considered heat-induced chemical changes.

Measurement of Changes in Honey

To study the effects of treatment on honey we must use some properties of honey as indices of change. Such properties should relate to the quality or commercial value of honey. The occurrence of granulation (of liquid honey), liquefaction or softening (of granulated honey), and fermentation as functions of storage conditions have been reported (Milum **et al.**, (1934), Fulmer **et al.**, (1934), Marvin (1930), Austin (1953). Color is easily measured. Gilbert (1934)) and particularly Milum (1948) have followed the changes in color of honey while in storage under different conditions.

As indicators of the acceptability of honey for table use, Europeans have for many years used the amount of certain enzymes and HMF in honey. They felt that heating of honey sufficient to destroy or greatly lower its enzyme content or produce HMF reduced its desirability for most uses. A considerable difference has been noted in the reports by various workers on the sensitivity of enzymes (largely diastase and invertase) in honey to heat. Only recently (White **et al.**, (1961), Hadorn **et al.**, (1962)) has it been noted that storage alone is sufficient to reduce enzyme content and croduce HMF in honey. Since some honey types frequently exported to Europe are naturally low in diastase, the response of diastase and invertase to storage and processing is of great importance for exporters.

Plan of Work and Results

Three cans of honey of high, intermediate, and low enzyme content were selected and portions put in jars and stored at six constant temperatures ranging from -20°C (-4°F) to 60°C (140°F). At appropriate intervals jars were removed from storage and analyzed for diastase, invertase, and HMF content.

The results were treated mathematically to obtain equations which express the half-life of the enzymes at any temperature. By using half-life (the time required for the enzyme content of any honey to fall to half of its original value) it is possible to combine the results on different honeys to get one expression. The equation allows us to calculate the half-life of honey diastase or invertase at any temperature over a range from about 10°C (50°F) to 80°C (176°F). The values obtained are approximations but they do give a good idea of what to expect in honey processing and storage. Table 1 shows values calculated from the equations.

The HMF values obtained on the stored honey samples were treated somewhat differently. The storage time needed to reach a given level of HMF in honey was obtained for each temperature and then a plot was made of this time against the temperature. A logarithmic relationship was found; but enough difference between honeys showed up that specific equations were not calculated. Table 2 shows approximate times for the honey to reach a level of 3 mg. HMF per 100 g. honey.

Table 1
Calculated Half-Lives of Honey Enzymes

Temperature °C	°F	Half-Life Diastase	Invertase
10	50	12,600 days	9,600 days
20	68	1,480 "	820 "
25	77	540 "	250 "
32.2	90	126 "	48 "
35	95	78 "	28 "
40	104	31 "	9.6 "
50	122	5.4 "	1.3 "
62.4	145	16 hr.	3 hr.
71	160	4.5 hr.	40 min.
80	176	1.2 hr.	8.6 min.

Table 2

Approximate Time Required for Honey to Attain 3 mg HMF/100 g at Various Temperatures

Temperature °C	°F	Time	
30	86	150 - 250	days
40	104	20 - 50	days
50	122	4.5 - 9	days
60	140	1 - 2.5	days
70	158	5 - 14	hrs.

Application of Results to Processing and Storage

At a temperature of 68°F, we find that diastase in honey has a half-life of 1500 days, nearly four years. Invertase is more heat-sensitive, with a half-life at 68°F of 800 days, or about 2¼ years. Thus there are no problems here. By an increase in storage temperature to 77°F, half the diastase is gone in 540 days (1⅓ years) and half the invertase disappears in 250 days, or about 8 months. These times are still quite long and there would seem to be nothing to be concerned about. However, as we know, temperatures in the 90's for extended periods are not at all uncommon; 126 days (4 months) will destroy half of the diastase and about 50 days (two months) will eliminate half the invertase at 90°. As we increase the temperature the times involved become shorter and shorter, until the processing temperatures are reached. At 130°F, 2½ days would account for half the diastase, and in 13 hours half the invertase is gone. A recommended temperature for pasteurization of honey is 145° for 30 minutes. At this temperature diastase has a half-life of 16 hours, and invertase only 3 hours. At first glance this might seem to present no problems, but it must be remembered that unless flash heating and immediate cooling is used, it can take a considerable time - many hours - for a batch of honey to cool from 145° to temperatures that are safe. If we proceed further to a temperature often recommended for preventing granulation, 160° for 30 minutes, the necessity of prompt cooling becomes highly important. At 160°, our data tell us that 2½ hours will destroy half the diastase, but half the more sensitive invertase will be lost in 40 minutes. This treatment, then, cannot be recommended for any honey in which a good enzyme level is needed.

The use of rapid heating and cooling for pasteurization of honey becomes even more attractive when we consider some data published by Townsend (1939). We have replotted his values on a logarithmic basis and obtained a straight line relating the log of time required to kill yeasts with the temperature. Values obtained from the line are shown in Table 3. Townsend's values show that 7.5 minutes at 145°F is sufficient to kill vegetating yeasts in honey and if the temperature is raised to 155°, the time is 1 minute, or less than 0.5 minute at 160°. With rapid heating and cooling, the higher temperatures can be safely used; the quotient, half-life of invertase divided by killing time for yeasts, ("Safety factor") actually becomes greater as the temperature is increased, changing from 24 at 145° to 80 at 160°F. The importance of cooling cannot be overemphasized but since special equipment is needed, it is often not done.

Table 3

Conditions for Yeast Destruction in Honey [1]

Temperature °F	Time Min.
128	470
130	170
135	60
140	22
145	7.5
150	2.8
155	1.0
160	0.4

Storage of Honey

In our work, we have seen that the damage done to honey by heating and by storage are the same; the lower temperatures of storage simply require much longer times to obtain the same result. It must be remembered that the effects of processing and storage are additive; it is for this reason that proper storage is so important. A few periods of hot weather can offset the

1 Calculated from data of Townsend (1939). Times required to destroy vegetative stages of 5 common honey yeasts in honey at 18.6% moisture. The last two values are extrapolated from the straight-line log curve.

benefits of months of cool storage - 10 days at 90° are equivalent to 100-120 days at 70°F. An hour at 145° in processing will cause changes equivalent to 40 days storage at 77°F.

Perhaps the easiest way for an individual to decide if he has storage or processing deterioration in his operation is to take samples of the fresh honey, being careful that they fairly represent the batch, place them in a freezer for the entire period, then allow to warm up to room temperature, and compare by color, flavor, and aroma with the honey that has been in common storage. In some parts of the United States the value of the difference can reach 1½ cents per pound in a few months. Such figures certainly would justify expenditures for temperature control.

Milum (1948) has published detailed charts showing the effect of storage at different temperatures on color of a number of honeys. Since it is rather difficult to obtain needed information from his charts, we have made some calculations from his data and in Table 4 may be seen an approximation of the effect of storage on honey color. Like the HMF production rates, to which it is related, different rates of discoloration were found for different honeys.

Recommended Procedures

The individual storing honey is on the horns of a dilemma; he must select conditions that will minimize undesirable granulation, fermentation, and heat damage. Fermentation is strongly retarded below 50°F and above 100°F. Granulation is accelerated between 55°-60°F and initiated by fluctuation around 50°-55°F. The best condition for storing unpasteurized honey would seem to be below 50°F, or winter temperatures over much of the United States. Warming above this range in the spring can initiate active fermentation in such honey, which is usually granulated and thus even more susceptible.

Table 4

Darkening of Honey in Storage [1]

Temp. of Storage °F	Darkening Rate (mm Pfund/month) White or Lighter	Extra Light Amber	Light Amber or darker
50	0.024	0.024	0.024
60	0.08	0.125	0.10
70	0.27	0.70	0.40
80	0.90	4.0	1.50
90	3.0	7.7	5.0
100	10.0	14.0	11.0

1 Calculated from data of Milum (1948).

Some of our progressive producers and packers are now using controlled temperature storage for honey, particularly in the warmer regions. Using the data we now have, we can definitely state that reducing the storage temperature of honey by 10°-15°F will reduce the rate of honey deterioration to about 1/3 to 1/6 of that at the higher temperature. Such a temperature reduction, which can easily be attained by air-conditioning, would reduce HMF production to 1/3, enzyme loss to 1/5 to 1/6, and color darkening rate to about 1/6 of the rate at the higher temperature. Loss of flavor and freshness would be expected to be reduced similarly. Thus honey can at any time of the year be more nearly like honey at its very best - fresh from the comb at extraction time.

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